FOOD-TESTING

B. A. BURRELL

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AN ELEMENTARY COURSE ON FOOD-TESTING

Percival T. Leigh Esq
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BY

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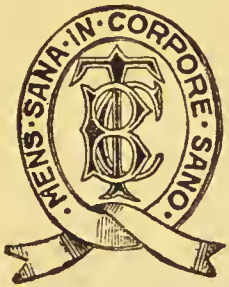

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PREFACE

SOME four years ago the author undertook, with much misgiving, the tuition of a newly-formed class for the study of food and its adulteration, the class being part of a scheme which the Leeds Education Committee had originated for the technical education of grocers.

At the outset he was confronted with two formidable difficulties—the entire absence of any chemical knowledge on the part of those attending, and the want of a suitable textbook; for, though there are many excellent treatises dealing with the analysis of food, they are written in technical language, and can only be appreciated by the trained chemist.

It therefore became a question of cautiously feeling the way, and devising simple experiments such as could be understood and performed by students very anxious to learn, but handicapped by the absence of the necessary mental tools. The present work is an attempt to knit the necessarily disconnected subjects into some semblance of a connected course.

The class has steadily grown both in numbers and enthusiasm, and the author ventures to hope that

his experience may be of use to similar classes established in other centres.

Free use has been made of the standard works devoted to the subject, and also of those invaluable publications the *Analyst* and the *British Food Journal*.

The illustrations of the starches, except those on pp. 64 and 65, are taken from Mr. E. G. Clayton's admirable 'Compendium of Food-Microscopy,' by the kind permission of the publishers, for which courtesy the author is much indebted. He also wishes to acknowledge his obligations to Mr. T. Fairley, F.R.S.E., a former President of the Society of Public Analysts, through whose instrumentality he undertook the class, and whose efforts for the spread of technical education are widely known and appreciated; and to Mr. S. C. Hodgson, B.A., Head-master of the School of Commerce, for his zealous co-operation in helping to make the class a success.

B. A. BURRELL.

LEEDS,
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CHAPTER I

INTRODUCTORY—ADULTERATION IN THE EARLY NINETEENTH CENTURY

The adulteration of food has no doubt been practised from a very early stage in the civilization of man. The Greek and Roman writers refer to the subject, and from early times in Great Britain and in Europe generally the practice was common, as shown by the various statutes enacted to secure the purity of beer, bread, spices, wine, etc.

In this country one of the first books devoted to the exposure of adulteration was written by Frederick Accum, and published in the year 1820, being entitled, 'A Treatise On Adulterations Of Food, & Culinary Poisons, Exhibiting The Fraudulent Sophistications Of Bread, Beer, Wine, Spirituous Liquors, Tea, Coffee, Cream, Confectionery, Vinegar, Mustard, Pepper, Cheese, Olive Oil, Pickles, And Other Articles Employed in Domestic Economy, And Methods Of Detecting Them.'

Historically, this work is of great interest, as it

enables a comparison to be made between the forms of adulteration prevalent at that time with those of the present day.

The list of articles in the title is fairly comprehensive, and it is supplemented in the Preliminary Observations by—'Indeed, it would be difficult to mention a single article of food which is not to be met with in an adulterated state; there are some substances which are scarcely ever to be procured genuine. And owing to the deterioration of almost all the necessaries and comforts of existence, it may be justly observed, in a civil as well as a religious sense, that "in the midst of life we are in death."'

In recent times much has been written in praise of good old English ale, supposed to be brewed from malt and hops only; but, if we are to believe Accum, few substances were more adulterated, the adulterants including 'black extract,' 'multum,' and 'bittern,' names used to disguise extracts of cocculus indicus, quassia and liquorice, and a mixture of copperas and cocculus indicus respectively. 'Beer heading' was a mixture of green vitriol, alum, and salt, used to produce 'cauliflower head.' Other substances were capsicum, coriander seeds, nux vomica, grains of paradise, sulphuric acid, opium, tobacco, etc. With the exception of quassia, none of the above are now met with, though arsenic, which was the cause of the beer scare a few years ago, is probably more noxious than anything in this formidable list.

Referring to wine, we find 'The sophistication of wine with substances not absolutely noxious to health is carried on to an enormous extent in the metropolis.

Many thousand pipes of spoiled cider are annually brought from the country, for the purpose of being converted into factitious port wine. There is in this city a certain fraternity of chemical operators, who work underground in holes, caverns, and dark retirements, to conceal their mysteries from the eyes and observations of mankind. These subterraneous philosophers are daily employed in the transmutation of liquors, and, by the power of magical drugs and incantations, raising under the streets of London the choicest products of the hills and valleys of France. They can squeeze Bordeaux out of the sloe, and draw champagne from an apple.' One department of this factitious wine trade was known under the name of 'crusters,' and was employed in lining the interior surface of empty wine-bottles, in part, with a red crust to simulate that deposited from port wine ; while others stained the lower extremities of bottle corks with a fine red colour, to make them appear, on being drawn, as if they had been in long contact with the wine.

The adulterants included alum, to brighten the colour of red wines ; Brazil wood and the husks of elderberries and bilberries, to impart a rich purple tint to port which was too light in colour ; oakwood sawdust, to give astringency ; and sugar of lead, to cure muddiness.

There is no doubt that even now it is possible to buy wines which contain artificial colouring matter, and others may be met with which are entirely innocent of the grape. Preservatives such as salicylic acid are also occasionally present.

Spirits were largely adulterated with water—an addition which is still very prevalent. Happily they are now free from such additions as tincture of grains of paradise or Guinea pepper.

Tea has been said to be the sheet-anchor of the grocer, and adulterated samples are now of rare occurrence; but Accum, quoting from the *Times* and the *Courier* for 1818, gives numerous records of trials and convictions for the dyeing, fabricating, and manufacturing of sloe, ash, elder, and other leaves in imitation of tea. These leaves were boiled, coloured with a mixture of logwood and verdigris, and then subjected to a baking process. Numerous convictions resulted, and fines were inflicted varying from £70 to £840. In one case counsel stated, 'When they were supposing they were drinking a pleasant and nutritious beverage they were in all probability drinking the produce of the hedges round the metropolis, prepared for the purpose of deception in the most noxious manner.'

Accum also quotes from the *Times* instances where dealers had been tried and convicted for selling coffee adulterated with ground burnt beans and peas, gravel or sand. From the evidence it would appear that many of the defaulters had no idea they were breaking the law, as several openly admitted in court that they had sold such mixtures for years. Chicory, which is now extensively used as an adulterant, is not mentioned. Apparently it was first used for this purpose about the year 1832, and there is no doubt that the admixture of this substance, and the ignorance which prevails as to the correct method of making

the infusion, are two potent causes for the decrease in the consumption of coffee, which is so noticeable during the last twenty to thirty years. Accum concludes his article on counterfeit coffee by stating that the adulteration of ground coffee with peas and beans is beyond the reach of chemical analysis. With our increased knowledge there is now no such difficulty.

In the chapter devoted to the adulteration of flour and bread, it is stated that this is one of the most common sophistications practised in the metropolis, where the goodness of bread is estimated entirely by its whiteness ; it is therefore usual to add a certain quantity of alum to the dough, the minimum quantity being about 4 ounces to a sack of flour weighing 240 pounds. The alum was not used as such, but was disguised under the name of 'sharp whites,' or 'stuff.' Another mineral adulterant was gypsum. These adulterants are now very rare, though cases have occurred within recent years where small quantities of alum have been detected, and gypsum has been found in muffins and oatcake to the extent of 1 and 10 per cent. respectively.

No mention is made of adulterated milk or butter, but cream was often adulterated with rice-powder or arrowroot ; and those who indulged in cheese ran a serious risk of being poisoned by red lead, used to colour the anatta.

At the present time milk is one of the most extensively adulterated foods ; and butter often contains an excessive quantity of water (over 16 per cent.), or is mixed with fat other than that derived from milk.

There is no danger of lead-poisoning from cheese, though there may be little or no fat, or, if fat be present, it may contain an admixture of margarine.

The adulteration of pepper is now comparatively insignificant, consisting of the admixture of either rice starch, pepper husk, or ground olive-stones, technically known as 'poivrette,' this latter requiring a skilled microscopist for its detection, and offering a great contrast to the readily detectable admixture mentioned by Accum of factitious pepper-corns, mixed to the extent of about 16 per cent. with the true pepper-corns. The factitious pepper-corns were made of a mixture of linseed-cake, common clay, and cayenne pepper, and it was only necessary to place some of the suspected corns in water, when they speedily fell to powder. As regards cayenne pepper, the adulteration was more deadly, consisting of red lead.

Vinegar was adulterated with sulphuric acid. The present fashion is to substitute pyroligneous acid for malt vinegar.

Those who ate pickles ran a serious risk of being poisoned by copper, as shown by the following recipe, taken from 'The Ladies' Library,' for pickling gherkins : 'Boil the vinegar in a bell-metal or copper pot ; pour it boiling hot on your cucumbers.' Another recipe, taken from 'The English Housekeeper,' recommended boiling the pickle with halfpence, or allowing it to stand twenty-four hours in a copper or brass pan. Preserved vegetables (especially peas) coloured green by copper are still to be bought, but the quantity of copper is comparatively small.

Olive oil generally contained lead, owing to its being pressed between leaden plates. This form of adulteration is now quite unknown, but of late years the substitution of cotton-seed oil, either wholly or in part, has been much practised.

Both lead and copper were extensively employed to colour the cheaper kinds of sweetmeats, which were also admixed with china clay, in some cases to such an extent that they would not burn when placed on the fire.

Accum's book concludes with two short chapters on food poisoned by copper and lead vessels. The following extracts will show what lamentable ignorance prevailed : 'Our food receives its quantity of poison in the kitchen by the use of copper pans and dishes. The brewer mingles poison in our beer by boiling it in copper vessels. The sugar-baker employs copper pans, the pastrycook bakes our tarts in copper moulds, the confectioner uses copper vessels, the oilman boils his pickles in copper or brass vessels, and verdigrease is plentifully formed by the action of the vinegar upon the metal.'

Regarding lead, we find, 'In Lancashire the dairies are furnished with milkpans made of lead, as they are supposed to throw up the cream better. In some parts of the North of England mint salad is prepared by bruising the mint in wooden bowls with a large ball of lead. It is also a common practice to have brewing coppers with the bottom of copper and the sides of lead ; and in the cider districts the leaden presses for squeezing the fruit have produced incalculable mischief.'

CHAPTER II

ELEMENTS AND COMPOUNDS—PROXIMATE COMPOSITION OF FOOD-STUFFS.

In foods there are certain substances which are used by the body : some contain a number, others perhaps only one or two.

These substances are composed of something simpler, and it is possible to continue this process of splitting up, till finally substances are obtained which cannot be simplified any further. Take butter as an example. The chemist has no difficulty in splitting it up into fat, water, casein or curdy matter, and salt. Then the question arises, what are each of these substances made of ? The fat is composed of about nine different substances, which can be finally resolved into carbon, hydrogen, and oxygen. The water, of hydrogen and oxygen ; the casein, of carbon, hydrogen, oxygen, nitrogen, sulphur, and phosphorus ; the salt, of chlorine and sodium. It is then natural to ask, what are carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, chlorine, and sodium made of ? The answer is, that with our present knowledge these substances cannot be simplified.

Chemists have agreed to call these simple sub-

stances 'elements.' At the present time there are about eighty of these so-called elements known, the world being composed of them and their different combinations. Some are very abundant, others are very scarce. Water is composed of oxygen and hydrogen, and the atmosphere mainly of oxygen and nitrogen; the newly discovered radium may be taken as an example of a scarce element.

In foods the elements occur in combination with one another to form what are called 'compounds.' Compounds contain at least two elements, often three, four, or five, etc.

Food-stuffs may generally be regarded as consisting of two portions—organic and inorganic. In butter, the fat and casein belong to the organic portion, as they both contain carbon, and may be completely burnt away, whilst the water and salt are inorganic bodies, not containing carbon. The organic portion always contains carbon in one or more of its compounds; and what is called organic chemistry is that portion devoted to the study of carbon compounds.

The greater part of dried food consists of the organic portion—viz., carbon—which is principally in combination with hydrogen, oxygen, and nitrogen, the combinations which may be effected between these elements being practically countless. Each combination produces a different substance, having special qualities of its own. The carbon compounds may be classified into groups or families which possess a certain likeness, and this also applies to the inorganic portion.

The elements which occur most frequently in the inorganic portion are calcium, chlorine, hydrogen, iron, magnesium, oxygen, phosphorus, potassium, silicon, sodium, and sulphur.

Foods always contain some of the following compounds :

Water, in varying quantities from 5 to 95 per cent.
Starch and sugar, which are related to one another, and known as carbohydrates.
Oils and fats.
Albuminoids.
Woody fibre.
Mineral matter.

After water, the starch and sugar families are the most abundant. They have the same elementary composition—viz., carbon, hydrogen, and oxygen—the two latter elements being in the same proportion as they are in water : two of hydrogen to one of oxygen. These are good examples of purely organic substances, and should leave no ash when burnt.

A very simple and delicate test for starch is described in Experiment I. (Time required, ten minutes) :

Some potato starch (quarter as much as will lie on a threepenny-piece) is placed in a test-tube (6 inches by $\frac{5}{8}$ inch). Fill one-third with cold water, shake, then heat gently over a Bunsen burner to gelatinize or 'crack' the starch. Add an equal volume of cold water from the tap, shake, and then completely cool the contents by holding the tube under the water-tap,

taking care not to allow any of the cooling water to enter the tube. When cold, add one drop of iodine solution ; a beautiful blue colour will be produced, which is due to the formation of a compound of iodine and starch, known as iodide of starch. Heat the tube in the Bunsen flame, and notice, as it becomes hot, the blue colour disappears, but reappears on cooling. This is a general test for starch, but it does not distinguish one kind from another, such as rice starch from potato starch. After the blue colour has been destroyed by heating, cooling may be effected by placing the test-tube in a 4-ounce beaker of cold water. Within half a minute the colour will reappear, commencing at the bottom of the tube and gradually spreading upwards.[1]

In the vegetable kingdom starch is present in great abundance ; for instance, rice contains about 75 per cent., wheat about 70 per cent., and there are large quantities in barley, beans, oats, peas, etc. The starch from these substances has the same chemical composition—viz., carbon, hydrogen, and oxygen united together—and it gives the same colour with iodine solution. To distinguish between the different starches the microscope must be used, when the different shapes and sizes are perceptible.

Sugars, of which there are a number, are valuable foods ; they occur in various plants, fruits, etc. The most important are cane-sugar (originally derived

[1] **Preparation of Iodine Solution.**—1·27 grammes of finely powdered iodine and 2 grammes of potassium iodide are mixed together and transferred into a 100 c.c. flask, which is filled up to the mark with distilled water, and shaken at frequent intervals till all is dissolved.

from the sugar-cane, but now largely obtained from the sugar-beet) and grape-sugar.

The different oils and fats are widely distributed, occurring both in the animal and vegetable kingdoms. The more expensive are very liable to adulteration ; for instance, butter fat is often mixed with margarine fat, and olive oil with cotton-seed oil.

Another very important part of a food is the flesh-forming portion, known as albuminoids. They are characterized by the presence of the element nitrogen. Included amongst the albuminoids are such substances as white of egg, the casein or curdy matter of milk, the fleshy portion of meat, and the legumins which occur in beans, peas, etc.

Woody fibre is present in most vegetable matter. It cannot be regarded as a food, but as a diluent to the substances which the body is capable of assimilating.

Of the mineral matters in food, the most important are common salt, carbonates and phosphates of lime and magnesia, siliceous matter, and various compounds of potash and of iron.

The stimulating properties of tea and coffee are due to the presence of certain organic compounds which have a powerful effect upon the human system.

CHAPTER III

PRELIMINARY OPERATIONS

Solution.—The property that a liquid possesses of dissolving a solid ; the liquid is called the solvent. Taking water as the solvent, it will be found to be capable of dissolving certain solid substances ; whilst other solids are not dissolved, and are therefore said to be insoluble.

EXPERIMENT II. (Time, five minutes.)

As much sulphate of magnesium (Epsom salts) as will lie on a penny is placed in a test-tube.[1] In another tube place a similar quantity of sand. Fill the tubes about one-third with water, take one in either hand, close the mouth of each with the thumbs, and shake for about one minute. Notice that during the shaking the sulphate of magnesium gradually becomes less, and eventually disappears ; also notice that, no matter how long the sand and water are shaken together, there is no diminution in the quantity of sand. Some substances are soluble in water, others are not.

[1] In performing this and other experiments where a test-tube is required, the most convenient size is $6 \times \frac{5}{8}$ inches, unless otherwise stated.

EXPERIMENT III. (Time, ten minutes.)

As much potassium nitrate (saltpetre) as will lie on a penny is placed in a test-tube with the same quantity of water as in Experiment II. Repeat the shaking; notice that it takes about three minutes for complete solution. Take another tube with the same quantities of potassium nitrate and water, but, instead of shaking, warm the contents of the tube over the flame of a Bunsen burner. Complete solution will occur in about one minute. Potassium nitrate is therefore more readily soluble in hot than in cold water.

Both of these solutions will be wanted for Experiments VII. and IX.

Apply heat to the tube containing the sand and water; note the result.

EXPERIMENTS IV. and V. (Time, ten minutes.)

Take the same quantities of powdered chalk and water as in Experiment II. Test its solubility in cold water with shaking, then ascertain whether hot water will be more effectual. Chalk is apparently insoluble in either cold or hot water. Allow the contents of the tube to cool, and use for—

EXPERIMENT V.

Add to the milky fluid 1 drop of hydrochloric acid (spirit of salt)—1 part of acid to 1 part of water; a violent effervescence takes place. When this has ceased, gently shake the tube to mix the contents; add another drop of hydrochloric acid, again shake, and continue the addition of acid with subsequent shaking, till there is no further effervescence and the

solution becomes quite clear. The experiment proves that chalk readily dissolves in hydrochloric acid, with effervescence. The solution is of a different nature to that where Epsom salts or saltpetre dissolve in water, both these substances remaining as such, in solution; whereas the chalk or calcium carbonate has been decomposed and no longer exists, one of its constituent parts escaping in the form of a gas (carbon dioxide), and causing the effervescence. The contents of the tube now consist of a solution of calcium chloride.

Evaporation.

EXPERIMENTS VI., VII., and VIII. (Time, forty minutes.)

Evaporation is the conversion of a liquid into vapour.

EXPERIMENT VI.—Place a tablespoonful of distilled water into a small porcelain basin. The basin is then placed on a tripod stand; should the dish be too small to rest upon the top of the tripod, it may be further supported on a pipeclay triangle. Heat over a Bunsen burner with a rose-top. Do not let the water actually boil, but as it gradually disappears lower the gas flame till at last the dish is dry and nothing remains.

EXPERIMENT VII.—Pour the contents of one of the tubes containing the potassium nitrate solution into another basin,[1] and heat as in Experiment VI.

[1] In performing this and other experiments where a porcelain basin is required, the most convenient size is 2¾ inches diameter, unless otherwise stated.

The water is dissipated into vapour, or evaporated, a white solid being left in the basin. This is the potassium nitrate which had been previously dissolved, and it has been recovered by the process called evaporation.

EXPERIMENT VIII.—In like manner evaporate the solution of calcium chloride. Notice that the white solid left in the basin has no resemblance to the calcium carbonate (chalk) from which it was made; also that it is difficult to dry, and that after being dried, if allowed to stand in the air, it becomes wet or deliquesces. The moisture is taken from the air.

Crystallization.

EXPERIMENT IX. (Time, twenty minutes.)

Evaporate the solution of potassium nitrate in the second tube to about half its bulk in a porcelain basin, then return it to the tube, which should be cooled under a stream of cold water from the tap. During the cooling, white needle-like particles appear: they are crystals of potassium nitrate, and have crystallized from the strong solution, which should be poured away from the crystals. This solution is known as the 'mother liquor.'

Precipitation.

EXPERIMENT X. (Time, five minutes.)

Take some of the calcium chloride (from Experiment VIII.)—sufficient to cover the bottom of the test-tube—fill the tube one-third with water, shake

till dissolved, then add 10 to 20 drops of sodium carbonate solution (strength, 10 per cent.); a white substance, or precipitate, is formed, which after a short time settles to the bottom of the tube. This is calcium carbonate, which has the same chemical composition as the chalk from which it has been made. It is called a precipitate, and the sodium carbonate solution is called the precipitant.

Filtration.

EXPERIMENT XI. (Time, twenty minutes.)

Filtration may be used to separate the precipitated calcium carbonate from the liquid in which it is suspended. Place a glass funnel (2 inches diameter) into the neck of a 2-ounce flask. A filter-paper (9 c.m. diameter) is folded thus  , then  ; opened partially, this now fits into the funnel. After shaking, pour the contents of the tube on to the filter-paper. Notice that the liquid coming through the filter-paper and dropping from the end of the funnel is quite clear and free from white particles, the white matter being left on the filter-paper. A solid in suspension has thus been separated from the suspending liquid. Now fill the test-tube with distilled water, and pour the water upon the filter-paper and its contents, but never completely fill the filter-paper; allow all the liquid to drain away from the funnel before adding fresh from the test-tube; repeat this twice. The precipitate is now washed from the precipitant. Remove the funnel from the

flask, and pour a few drops of dilute hydrochloric acid upon the washed precipitate in the filter ; there is effervescence, and the same action goes on as when the original chalk was dissolved in the first instance.

CHAPTER IV

ORGANIC MATTER, ETC.

After water, organic matter forms the principal part of most foods; it may be recognized by the charring or blackening which occurs when it is burnt.

Experiment XII. (Time, fifteen minutes.)

Take two porcelain crucibles ($1\frac{1}{2} \times 1$ inch); into the first, place as much starch as will cover a threepenny-piece, and into the second, the same quantity of white sugar. Use the same supports for heating as in evaporation (Experiment VI.), but remove the rose-tops from the Bunsen burners. Regulate the gas-flame so that the upper portion impinges on the bottom of the crucibles, thus utilizing the hottest portion of the flame; the contents will turn black, take fire, and gradually burn away, both starch and sugar consisting of organic matter only.

Mineral Matter.

Experiment XIII. (Time, ten minutes.)

In the same manner ignite the same quantities of sodium chloride (common salt), sand, and sodium

carbonate in separate porcelain crucibles. There is no change, as these are examples of non-volatile mineral matter.

Substances containing Organic Matter and Mineral Matter.

EXPERIMENT XIV. (Time, forty-five minutes.)

In the same manner ignite in separate porcelain crucibles chicory, tea, and fine oatmeal, in each case as much as will lie on a penny. The greater portion burns away, but each will leave a small quantity of ash or matter which cannot be burned; this is the mineral matter naturally occurring in these substances. The ignition should be continued as long as any black particles remain, and after the oatmeal has ceased to flame, the crucible should be loosely covered with a lid; this will hasten the ignition. It may be further helped by occasionally scraping the white ash from the central core of charcoal; a nickel wire may be used for the purpose. Be careful not to break up the lump of charcoal.

Carbonates.

EXPERIMENT XV. (Time, five minutes.)

When dissolving the chalk in hydrochloric acid (Experiment V.) a violent effervescence was noticed, due to the evolution of carbon dioxide gas. This is characteristic of carbonates; and the test may be amplified by ascertaining whether the evolved gas extinguishes a lighted match. As much sodium

carbonate as will lie on a threepenny-piece should be placed in the bottom of a test-tube ; add a few drops of hydrochloric acid, and hold a lighted match just inside the top of the tube. The flame will be extinguished.

Siliceous or Sandy Matter.

EXPERIMENT XVI. (Time, twenty minutes.)

Take as much sand as will cover a threepenny-piece, place in a porcelain crucible, and ignite for five minutes ; there is no change. Allow the crucible to cool, transfer the contents to a test-tube, fill one-third with dilute hydrochloric acid (1 acid and 1 water), keep just short of boiling for ten minutes ; there is no change. It may be taken as a general statement, that any substance present in foods which resists this combined treatment, and is white in colour, is siliceous or sandy matter.

Lead Compounds.

EXPERIMENT XVII. (Time, fifteen minutes.)

As much lead acetate (sugar of lead) as will lie on a threepenny-piece is dissolved in a test-tube nearly full of distilled water, by warming over a Bunsen burner. Use this solution for the following tests ; first cool under the water-tap, and divide the solution into three test-tubes, A, B, and C :

A. Add about the same volume of sulphuretted hydrogen water ; the solution turns black, owing to the formation of black sulphide of lead.

B. Add a few drops of potassium chromate solution; yellow chromate of lead is formed.

C. Add a few drops of sulphuric acid; white sulphate of lead is formed.

Allow the test-tubes to stand for five minutes; the respective precipitates will have settled to the bottom of the tubes, and further proof will be obtained that the changes in colour are really due to the formation of different-coloured solid substances.

Methods based upon the above tests are used to detect lead compounds, which sometimes occur in citric and tartaric acids, cream of tartar, lemonade, etc. Lead compounds are poisonous, and should not be present in any article intended for human consumption.

NOTE.—Strength of test solutions or reagents: Sulphuretted hydrogen water, saturated; potassium chromate solution, 5 per cent.; sulphuric acid, 5 per cent. real acid.

Copper Compounds.

EXPERIMENT XVIII. (Time, fifteen minutes.)

In the same manner dissolve a similar quantity of copper sulphate (blue vitriol) in water, and divide into three test-tubes, A, B, and C:

A. Add ammonia solution drop by drop; note that the light blue solid which at first appears gradually dissolves on the continued addition of ammonia, the final result being a dark blue coloured liquid.

B. Add a solution of potassium ferrocyanide; a chocolate-coloured precipitate is formed.

C. Pour the solution of copper sulphate into a small porcelain basin, then immerse for a few minutes a bright piece of steel, such as a penknife blade. On withdrawing the steel from the liquid it will be found to be copper-coloured, owing to the deposition of metallic copper on the steel. Methods based upon the above tests are used to detect copper compounds, which are sometimes used to impart a green colour to tinned vegetables, such as peas, etc. Like lead compounds, they are poisonous, and should not be used.

NOTE.—Strength of test solutions or reagents: Ammonia solution, 1 part of 0·880 ammonia mixed with 3 parts of water; potassium ferrocyanide solution, 5 per cent.

Borax and Boric Acid.

EXPERIMENT XIX. (Time, ten minutes.)

In a porcelain basin place as much powdered borax as will lie on a threepenny-piece, add half a teaspoonful (3 c.c.) of methylated spirit, and then 5 drops of strong sulphuric acid. Mix by means of a glass rod. Kindle the mixture. Notice that it burns with a vivid green flame. Repeat the experiment with boric acid (in this case it will not be necessary to add sulphuric acid); the same coloured flame will be obtained. Now try the effect of using methylated spirit and sulphuric acid only. The green-coloured flame is quite absent, and is therefore caused by the presence of borax or boric acid, for which it constitutes a delicate test.

EXPERIMENT XX. (Time, fifteen minutes.)

The same quantities (as in Experiment XIX.) of borax and boric acid respectively are placed in separate porcelain basins; to each add 3 c.c. of dilute hydrochloric acid (1 in 4); thoroughly mix by means of a glass rod till dissolved; place the same quantity of dilute hydrochloric acid in a third basin. Immerse in each a strip of turmeric-paper, so that only half the paper is in the liquid. In the course of five minutes the colour of the papers immersed in the solutions of borax and boric acid will have changed to a reddish-brown, but no alteration will occur in that immersed in hydrochloric acid only.

In three similar basins pour a little sodium carbonate solution (5 per cent.); withdraw the strips of turmeric-paper from the first set of basins, and immerse them in the sodium carbonate solution; the papers from the borax and boric acid quickly turn a bluish-black colour; the third strip turns a reddish-brown colour.

Borax and boric acid are used as preservatives, and are sometimes found in cream, milk, butter, bacon, pork-pies, sausages, jams, etc.; also in cheap wines.

Acids, Alkalies, Neutral Substances.

EXPERIMENT XXI. (Time, five minutes.)

Take three porcelain basins. Into A pour a few drops of dilute sulphuric acid (5 per cent.), into B a similar quantity of vinegar, and into C a solution of

tartaric acid (made by dissolving as much tartaric acid as will lie on a threepenny-piece in one-third of a test-tube full of water). Into each dip a strip of blue litmus-paper. Note the result. These substances which turn blue litmus-paper red are called acids, and are said to have an acid reaction. Wash the basins and use them for—

EXPERIMENT XXII. (Time, five minutes.)

Into A pour a few drops of caustic-soda solution (5 per cent.) ; into B some washing-soda solution (made from washing soda, and using similar quantities to those for the solution of tartaric acid in Experiment XXI.) ; into C some ammonia solution (1 in 4). Into each dip a strip of red litmus-paper. Note the result. These substances which turn red litmus-paper blue are called alkalies, and are said to have an alkaline reaction. Blue and red litmus-paper are called indicators, as they indicate the reaction of the substance to be tested.

EXPERIMENT XXIII. (Time, five minutes.)

Make solutions of sodium chloride (common salt), potassium nitrate (saltpetre), and sugar respectively, by dissolving as much as will lie on a threepenny-piece in one-third of a test-tube of water. Pour into three basins, and ascertain their reaction with strips of blue and red litmus-papers. There is no change in colour, these substances being neutral—*i.e.*, neither acid nor alkaline.

Formation of Inorganic Neutral Substances.

EXPERIMENT XXIV. (Time, ten minutes.)

A neutral substance may be formed by neutralizing an acid with an alkali, or *vice versa*. Into a porcelain basin pour about 6 c.c. (teaspoonful) of dilute hydrochloric acid (1 in 4); introduce a small piece of blue litmus-paper, ☐ size. Add, drop by drop, caustic-soda solution (5 per cent.), stirring after each addition with a glass rod, to thoroughly mix. At a certain point the colour of the paper changes into a reddish-blue tinge, showing the liquid is neutral—*i.e.*, neither acid nor alkaline. One drop more of the caustic-soda solution turns the paper completely blue, the liquid being now alkaline. The clean filler of a fountain-pen will be useful as a dropper; be careful not to let the caustic-soda solution drop directly on to the litmus-paper.

CHAPTER V

COFFEE AND CHICORY

COFFEE 'beans' are the fruit of a small tree which grows in tropical countries; they are prepared for consumption by careful roasting, and the roasted product is ground to powder.

Chicory is the root of a plant called wild endive, grown in England and other European countries. The root is roasted and ground to powder; it is then used as an adulterant of coffee.

Roasted Coffee.	*Roasted Chicory.*
1. Contains a considerable quantity of fat (about 12 per cent.).	Contains but little fat (about 1 per cent.).
2. Contains but little sugar (about 1 per cent.).	Contains a considerable quantity of sugar (about 20 per cent.).
3. Does not readily mix with cold water, but floats.	Readily mixes with cold water, and sinks.
4. Does not readily colour cold water.	Readily colours cold water.
5. Is hard, and not easily broken.	Is soft, and easily broken.
6. The ash only contains traces of siliceous matter.	Ash contains a distinct quantity of siliceous matter.
7. Does not stick together after it has been exposed to the atmosphere.	Becomes sticky after it has been exposed to the atmosphere for a few days.
8. Contains a substance called caffeine, which has a powerful effect upon the nervous system.	Does not contain caffeine.

EXPERIMENT XXV. (Time, fifteen minutes.)

Half fill two 4-ounce beakers with water from the tap ; place them side by side on a sheet of white paper. Into one carefully sprinkle as much powdered coffee as will lie on a penny, and into the other an equal quantity of powdered chicory. Allow the beakers to stand undisturbed for ten minutes ; it will then be found that nearly all the coffee is still floating on the surface, and that the water is hardly coloured, whereas the greater part of the chicory has sunk, and the water is strongly coloured. The fat contained in coffee helps it to float, and prevents the water wetting it.

EXPERIMENT XXVI. (Time, twenty-five minutes.)

Place as much coffee as will lie on a penny in a porcelain basin ; nearly fill with cold water, and bring the contents to the boil over a Bunsen burner, stirring with a glass rod. Boil gently for three minutes. Remove the burner, and allow the basin to stand five minutes. Pour the liquid into a 4-ounce beaker, being careful not to disturb the 'grounds.' Fill the beaker with water, and place it on a sheet of white paper. Stir the contents. Examine the 'grounds' left in the basin by pressing with the end of a glass rod ; notice that they are hard. Repeat the experiment with the same quantity of chicory. Notice that the chicory 'grounds' are soft, and that the chicory infusion is much darker

than the coffee infusion, thus confirming the result obtained when using cold water.

EXPERIMENT XXVII. (Time, two to three days.)

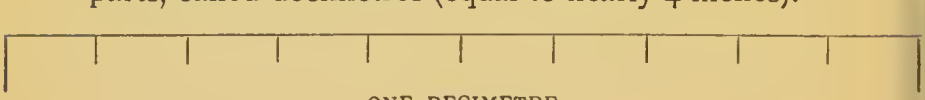
The student should try the effect of exposing powdered coffee and chicory to the atmosphere for several days at his own house.

CHAPTER VI

MEASURES AND WEIGHTS

THE French metrical system is now generally used in chemical operations. Being a decimal system, calculations are much facilitated.

The unit of length is called a *metre* (equal to 39·37 English inches). It is divided into ten equal parts, called decimetres (equal to nearly 4 inches).



ONE DECIMETRE.

The decimetre is again divided into ten equal parts, called *centimetres.*

ONE CENTIMETRE.

The centimetre is divided into ten equal parts, called *millimetres.*

Thus 1 decimetre (dcm.) = 0·1 m.[1]
1 centimetre (cm.) = 0·01 m.
1 millimetre (mm.) = 0·001 m.

The unit of *volume is the cubic centimetre.*

One thousand c.c.[2] = 1 cubic decimetre or 1 litre.

[1] m. = metre. [2] c.c. = cubic centimetre.

The unit of *weight is the weight of* 1 *cubic centimetre* of distilled water at a temperature of 4° C.

This is called a *gramme.*

The gramme is divided into ten equal parts, called *decigrammes.*

The decigramme is divided into ten equal parts, called *centigrammes.*

The centigramme is divided into ten equal parts, called *milligrammes.*

EXPERIMENT XXVIII. (Time, ten minutes.)

Compare a box of weights with the following :

Whole Numbers.

50 grammes.	20 grammes.	10 grammes.	10 grammes.	5 grammes.
	1 gramme.	1 gramme.	1 gramme.	2 grammes.

Fractions.

0·5 gramme.	0·2 gramme.	0·1 gramme.	0·1 gramme	0·05 gramme.
	0·01 gramme.	0·01 gramme.	0·01 gramme.	0·02 gramme.

Do not touch the weights with the fingers, but use the small forceps for lifting.

The milligramme is sometimes used as the basis of the small weights.

Thus 0·5 gramme = 500 milligrammes = $\frac{1}{2}$ gramme.

0·2	,,	= 200	,,	= $\frac{1}{5}$	,,
0·1	,,	= 100	,,	= $\frac{1}{10}$	,,
0·05	,,	= 50	,,	= $\frac{1}{20}$	,,
0·02	,,	= 20	,,	= $\frac{1}{50}$	,,
0·01	,,	= 10	,,	= $\frac{1}{100}$	,,

NOTE.—The metre was intended to be the $\frac{1}{10,000,000}$ part of the distance of the Pole from the Equator. Later measurements show that this is not quite correct, but the value and convenience of the metric system is not affected thereby.

CHAPTER VII

WEIGHING

A CHEMICAL balance is a very delicate instrument, and requires careful treatment. It is enclosed in a glass case, in order to prevent draughts interfering with the accuracy of the weighing, and also to preserve the instrument.

The milled head in front of the balance-case, on being turned, actuates mechanism which prevents the balance swinging when not in use.

Nothing must be added or removed when the balance is swinging; it must always be placed out of gear by turning the milled head before any addition or subtraction is made.

The glass case being closed, turn the milled head, and note the number of divisions the pointer swings on either side of the central line marked on the ivory scale placed at the base of the pillar. If these are equal, the balance is in equilibrium.

The weights are placed on the right-hand pan, and the substance to be weighed on the left-hand pan.

EXPERIMENTS XXIX., XXX., and XXXI. (Time, about thirty minutes.)

To Weigh a Small Porcelain Crucible. — Place a 10-gramme weight on the right-hand pan, set the

balance swinging, and watch the pointer. If the 10-gramme weight is too heavy, put the balance out of gear, remove the weight, and try 5 grammes. If this is too light, put the balance out of gear, add 2 grammes, etc., adding the smaller weights one by one in the descending order of magnitude, being careful to put the balance out of gear before each addition or subtraction, and to try each successive weight. Do not put the fractional weights one on the top of the other, but space them out on the pan, to facilitate the final reading of the weights. Having obtained the weight of the crucible by adding together the weights on the pan, check the number so obtained by comparing it with the empty spaces in the weight-box.

Find the weight of a new penny and the weight of a worn penny, or other new coin and a worn one of the same denomination.

If the substance to be weighed has been ignited, or dried in a hot-water oven, wait till it is cold before placing on the balance-pan, or an error will result. Do not put the material to be weighed direct on to the balance-pan, but in a basin, crucible, or watch-glass, the weight of which has been previously obtained.

CHAPTER VIII

ESTIMATION OF THE MINERAL MATTER OR ASH, AND SILICEOUS MATTER IN CHICORY, COFFEE, AND TEA

EXPERIMENT XXXII. (Time, two and three-quarter hours.)

Ascertain that the balance is in equilibrium. Weigh a porcelain crucible ($1\frac{3}{4}$ inches diameter); note the weight. Place an additional 5 grammes on the right-hand balance-pan, and weigh this quantity of chicory. Place the crucible on a pipeclay triangle, supported on a tripod or retort stand; carefully ignite over a Bunsen burner, keeping the gas low till the chicory has ceased to smoke or flame; then slightly increase the gas supply. Continue the ignition till no black particles are observable. Do not break up the lump of charcoal in the crucible, but at intervals scrape off the white ash on its surface to one side of the crucible. Allow the crucible to cool, and weigh immediately. The increase in weight × 20 = the percentage of ash.

In like manner estimate the ash of coffee and tea. The tea ash will have a slight greenish tint; the others will be white or reddish-white.

EXAMPLE OF WEIGHING THE ASH OF CHICORY.

Weight of crucible	8·35 grammes	Before ignition
Weight of chicory taken ...	5·00 „	
Weight of crucible and chicory	13·35 „	
Weight of crucible + ash	8·61 grammes	After ignition.
Weight of crucible ...	8·35 „	
Weight of ash	0·26 gramme.	

Five grammes were taken, therefore $0{\cdot}26 \times 20 = 5{\cdot}2$ per cent. of ash in chicory. The numbers obtained should fall within the following limits :

Chicory ash ...	4·5 per cent. to	7·5 per cent.
Coffee ash ...	3·5 „	4·5 „
Tea ash	5·0 „	7·0 „

Estimation of Siliceous or Sandy Matter in Chicory, Coffee, and Tea.

EXPERIMENT XXXIII. (Time, two hours.)

Use the ash of the chicory obtained in Experiment XXXII.

Measure 20 c.c. of dilute hydrochloric acid (1 in 4), and cautiously add about 5 c.c. to the chicory ash in the crucible ; notice the effervescence and therefore the presence of carbonates. Rinse round the crucible, and pour contents into a 4-ounce beaker. Repeat the operation, using more of the dilute hydrochloric acid, till eventually the whole of

the 20 c.c. have been used, and the crucible washed free from insoluble matter. Place the beaker on the hot-plate, heat to boiling, and boil for two minutes. Remove the beaker, and let it stand for three minutes; then pour off the top liquid through a 9-centimetre filter-paper. Repeat this treatment with another 20 c.c. of hydrochloric acid, then with two separate quantities of distilled water (20 c.c. each time), passing all the liquids through the same filter-paper.

Place the funnel and paper in the beaker containing the greater part of the insoluble matter, which is then dried in the hot-water oven. When dry, the contents of the beaker and the matter adhering to the paper are carefully brushed into the crucible used for estimating the ash, the weight of which should have been checked previously. The crucible and contents are then carefully ignited for about two minutes over a small Bunsen flame. Allow the crucible to cool, weigh, and subtract the weight of the crucible from the total weight; the difference is siliceous matter, which, when multiplied by 20, gives percentage:

Weight of crucible and siliceous matter	8·44 grammes.
Weight of crucible	8·35 „
Weight of siliceous matter ...	0·09 gramme.

Five grammes were taken, therefore $0{\cdot}09 \times 20 = 1{\cdot}8$ per cent. of siliceous matter in chicory.

In like manner estimate the siliceous matter in

coffee and tea. The numbers obtained should fall within the following limits :

Chicory ...	...	1 to 4 per cent.
Coffee ...	...	trace.

Tea seldom exceeds 0·5 per cent., and is generally much less.

The estimation of the siliceous matter in the coffee and tea should be worked simultaneously to save time.

CHAPTER IX

SUGAR

'The sugar thou gavest me, 't was a pennyworth, was 't not?'—*Henry IV.*

THERE are a number of varieties of sugar, but the two most important are cane-sugar and grape-sugar.

Cane-sugar, as its name implies, was originally derived from the sugar-cane, a plant growing in tropical countries; but much is now derived from the sugar-beet, largely grown in various parts of Europe.[1]

Cane-sugar or beet-sugar has a different appearance and is much sweeter than grape-sugar, and it is that variety of sugar which is in general use for household purposes.

In addition to the difference in the appearance and taste, cane-sugar behaves differently to grape-sugar when tested with Fehling's solution.

EXPERIMENT XXXIV. (Time, forty minutes.)

Make a 1 per cent. solution of cane-sugar by weighing 0·5 gramme, and dissolving in 50 c.c. of

[1] Though derived from a different plant, the sugar has the same chemical composition as that from the sugar-cane.

distilled water; also make a solution of grape-sugar of similar strength.

Place 5 c.c. of Fehling's solution in a test-tube, add an equal bulk of water, warm, and then add 3 or 4 c.c. of the cane-sugar solution; boil gently, and note the result.

Repeat the experiment with the grape-sugar solution, and compare the contents of the two tubes.

The precipitate is red oxide (suboxide) of copper.

At a later stage the student should prepare a small quantity of Fehling's solution.

Preparation of Fehling's Solution.—Powder finely in a mortar 6·9 grammes of pure sulphate of copper, dissolve in about 50 c.c. of distilled water, add 1 drop of pure sulphuric acid, and then more distilled water, till the solution measures 100 c.c. Transfer to a stoppered bottle, and label 'Sulphate of Copper Solution.'

Weigh 35 grammes of pure Rochelle salt, and dissolve in about 70 c.c. of distilled water.

Weigh 10 grammes of caustic soda, and dissolve in about 20 c.c. of water; add the caustic-soda solution to the solution of Rochelle salt, and make up the whole to 100 c.c. Transfer to a bottle, of which the stopper has been smeared with paraffin-wax or vaseline. Label 'Alkaline Rochelle-salt Solution.'

When Fehling's solution is wanted, mix equal measures of the two solutions, adding the copper-sulphate solution to the alkaline Rochelle-salt solution.

White Cane-sugar.

There is a widespread belief that sugar is often adulterated with sand or starch. Though this may have been true fifty or sixty years ago, such clumsy additions are now practically unknown,[1] and it may be safely stated that at the present time there is no article of food which is so unlikely to be impure as white sugar.

Sugar may be easily tested for these impurities by taking advantage of its ready solubility in cold water.

EXPERIMENTS XXXV. and XXXVI. (Time, ten minutes.)

A teaspoonful of white sugar is placed in a 2-ounce beaker, and dissolved in about four teaspoonfuls of cold water. If it dissolves completely to a clear liquid, showing no turbidity or sediment, neither starch nor sand can be present, as both are insoluble in cold water, the sand settling down as a heavy sediment, and the starch remaining in suspension and forming a turbidity. Should the water be turbid, then it will be necessary to warm, cool under the tap, and add iodine solution, as in Experiment I.

As it would be very difficult to buy sugar adulterated with sand or starch, the student should mix one teaspoonful of sugar with a quarter as much sand and starch respectively as will lie on a three-penny-piece. Test the mixture as in the previous experiment, and note the result.

[1] At the Thames Police Court, in 1903, a tradesman was fined for selling sugar containing 33 per cent. of starch.

Demerara Sugar

is derived from the sugar-cane, and is sometimes fraudulently simulated by 'yellow crystals,' which are ordinary beetroot-sugar dyed yellow. Such substitution may generally be detected by—

EXPERIMENT XXXVII. (Time, ten minutes.)

In two porcelain basins place a teaspoonful of genuine Demerara sugar and 'yellow crystals' respectively. Moisten each with about half a teaspoonful of water, and then add a few drops of dilute hydrochloric acid (1 : 1). With the genuine Demerara sugar no change in colour is apparent, but the 'yellow crystals' usually become a bright purple-pink colour.[1]

[1] It is curious that this form of adulteration is mainly confined to the South of England, very few cases being recorded for the North.

CHAPTER X

TESTING OLIVE OIL, LARD, ETC., FOR COTTON-SEED OIL

EXPERIMENT XXXVIII. (Time, one hour.)

Olive oil is sometimes adulterated with cotton-seed oil. Such adulteration may be detected by means of a test named after its discoverer, Halphen.

Three c.c. of the oil are placed in a clean dry test-tube, an equal volume of Halphen's test is added, and the two are mixed together; the test-tube is loosely stoppered with a plug of cotton-wool, and placed in a beaker of brine, which is gradually brought to the boil and kept boiling for about fifteen minutes.[1] The heating should be done in a draught cupboard.

If as little as 5 per cent. of cotton-seed oil is present, a red colour is produced, the colour varying in intensity with the quantity of cotton-seed oil present. Apply the test to cotton-seed oil, pure olive oil, and an olive oil containing about 5 per cent. of cotton-seed oil; also to pure lard, lard compound, and sweet oil.

[1] The beaker should not be heated directly over the naked flame, but placed on an iron plate or sand-bath.

Some samples of cotton-seed oil do not react with this test ; a negative result is, therefore, not absolute proof of the absence of cotton-seed oil.

NOTE.—Halphen's test is made as follows: Powdered sulphur is dissolved in carbon bisulphide so as to form a 1 per cent. solution. Some of this solution is then mixed with an equal volume of amyl alcohol, and preserved in a well-stoppered bottle.

Carbon bisulphide is a liquid possessing an unpleasant smell, and is extremely inflammable ; and until the student has more experience it is not advisable for him to make the test liquid ; it should be bought ready made up. In applying the test, care must be taken not to bring the bottle containing the test liquid near a light.

CHAPTER XI

EXAMINATION OF SAUSAGES FOR BORIC PRESERVATIVE COMPOUNDS, AND STARCH

EXPERIMENT XXXIX. (Time, one and three-quarter hours.)

Apparatus Required.—Balance and weights, porcelain basin (4½ inches diameter), 100 c.c. measuring cylinder, tripod stand, Bunsen burner and rose-top, glass rod, muslin, funnel (3 inches diameter), flask (10 ounces), separating funnel, beaker (4 ounces), three porcelain basins (2¾ inches diameter), pipeclay triangle, iodine solution, two test-tubes, bone spatula, methylated spirit, strong sulphuric acid, turmeric-paper, hydrochloric acid, sodium carbonate solution.

1. Cut off about one-quarter of a sausage.

2. Weigh it. It should weigh about 21 grammes (¾ ounce).

3. Place it in a porcelain basin (4½ inches diameter); add 100 c.c. of tap-water; support the basin on a tripod stand arranged over a rose-topped Bunsen burner.

4. Light the burner low, and continue the heating for about twenty-five minutes, during which time the

sausage material should be thoroughly mixed with the water by means of a glass rod.

5. Place some coarse muslin in a funnel (3 inches diameter), and arrange the funnel that the filtrate may flow into a flask.

6. Filter the contents of the basin through the muslin.

7. The solid matter which does not pass the muslin may be thrown away. While the filtrate is still hot, transfer it to a separating funnel.

8. Within a minute or two the contents of the funnel will separate into two portions, the fatty matter rising to the top, and the water remaining at the bottom.

9. By means of the tap, run off the water into a clean beaker, and divide it into two approximately equal portions.

10. Evaporate one portion in a porcelain basin to dryness, and ignite for about fifteen minutes.

11. While this ignition is proceeding, test the second half of the liquid for starch with the iodine test described on p. 10.

12. Allow the basin containing the evaporated and ignited portion to cool, divide the ash into approximately equal portions; leave one half in the original basin, transfer the other half to another basin.

13. To one basin add about 10 c.c. of methylated spirit and 5 drops of strong sulphuric acid, and proceed as in Experiment XIX. A green flame, which becomes especially marked when the spirit is being exhausted, indicates the presence of boric compounds—either borax or boric acid.

14. To the ash in the second basin add about 5 c.c. of dilute hydrochloric acid (1 in 4), and test with turmeric-paper as directed in Experiment XX.

(*a*) These experiments show that borax or boric acid are soluble in water, and may therefore be dissolved and separated from most of the organic matter of which the sausage mainly consists.

(*b*) Under ordinary conditions these boric compounds are not volatilized by heat, but when treated with alcohol and sulphuric acid they become volatile, as shown by the vivid green flame given by the burning alcohol.

(*c*) That, in addition to the flesh food of which sausages are supposed to mainly consist, they generally contain boric preservative compounds and much starchy matter.

It is, however, quite possible to buy sausages which do not contain boric preservative compounds; if proper care is taken in their manufacture, such preservatives are unnecessary. It has been stated that sausages will not keep unless a preservative is added; but, as there is no difficulty in keeping (for a reasonable time) the meat from which they are made, this statement means that the intestines which form their skin have not been properly cleaned from the putrefactive bacteria which are always present in large numbers in this portion of the animal.

In buying sausages, always insist upon a guarantee that they are free from boric compounds. By so doing you will avoid taking a powerful drug which the system does not require, and at the same time you will have the satisfaction of knowing that the

sausages have been produced under cleanly conditions.

The following is taken from the *British Food Journal*, 1909, p. 105: 'At the County of London Sessions, on May 19, before Mr. R. Wallace, K.C., Chairman, and other Justices, a tradesman appealed against a conviction by Mr. F. Mead, at Marlborough Street Police Court, on December 11, 1908, and a fine of £2 and £5 5s. costs, for selling sausages containing 22·4 grains of boric acid to the pound. After hearing evidence, at the same Court, on June 11, Mr. Wallace delivered judgment as follows: "I find that the sausages were sold to the prejudice of the purchaser; that they contained something that rendered them not of the nature, substance, and quality demanded by the purchaser. The appeal is dismissed with costs."'

CHAPTER XII

EXAMINATION OF TINNED PEAS FOR COPPER

Apparatus Required. — Glass funnel ($5\frac{1}{2}$ inches diameter), cork to fit, filter-stand, jar or basin, tin-opener, balance and weights, porcelain basin, pipe-clay triangle, tripod stand, Bunsen burner, spatula, porcelain pestle and mortar, two 50 c.c. measuring cylinders, nitric acid, iron plate, glass funnel (2 inches diameter), filter-paper (9 cm.), blue litmus-paper, ammonia solution, acetic acid, potash ferrocyanide solution.

EXPERIMENT XL. (Time, about two and a quarter hours.)

1. A glass funnel ($5\frac{1}{2}$ inches diameter) is fitted at the apex with a cork, which has had four channels cut lengthwise.

2. Arrange the funnel in a wooden filter-stand, with a basin or jar to catch the liquid draining from it.

3. Open the tin of peas, and pour the contents into the funnel. After the liquor has drained away, fill up the funnel twice with tap-water, allowing the first lot to drain away before adding the second.

4. Now weigh approximately 50 grammes of the washed peas in a porcelain basin.

5. Support the basin by means of a pipeclay triangle and tripod over a Bunsen burner ; ignite very gently for the first ten minutes, then turn the gas on full, and continue the ignition for about one hour.

6. Turn out the gas, and allow the basin to cool for five minutes ; transfer the contents to a small porcelain mortar, and grind it up fine with the pestle.

7. Retransfer the ground mass back to the basin, and continue the ignition for half an hour longer. Turn out the gas, and allow the basin five minutes to cool.

8. Add 15 c.c. of nitric acid (1 : 1), and warm gently on the hot plate for about ten minutes ; filter the liquid, using a 9 centimetre filter-paper, into a 50 c.c. graduated measuring cylinder. After the liquid has passed through the filter-paper, rinse out the basin with tap-water, pouring the washings on to the filter-paper. Allow the water to drain through. Wash a second or third time, till the total filtrate measures about 30 c.c.

9. Drop a small piece of blue litmus-paper into the liquid ; add ammonia (1 : 1) little by little, shaking after each addition till the paper turns blue. Now add about 5 c.c. more ammonia solution.

10. Filter the turbid liquid through a 9 centimetre filter-paper. If copper compounds were present in the peas, the filtered liquid will be of a blue colour, the depth of the colour depending upon the quantity of copper present.

11. This is a practical application of Experi-

ment XVIII., and to further confirm the presence of copper the ferrocyanide test should be applied.

12. Add a small piece of blue litmus-paper to the blue-coloured liquid ; then acetic acid drop by drop, with constant shaking, till the paper turns red. Now add about 5 c.c. of the ferrocyanide solution. The presence of copper is confirmed by the liquid becoming chocolate-coloured.

It is a common error to say that coppered peas contain sulphate of copper, for, though this substance is used in the greening process, it becomes changed into another compound of copper, which is nearly insoluble in water, sulphate of copper being readily soluble. The correct way is to state that the peas contain copper compounds *equal* to so much crystallized sulphate of copper.

The quantity of copper compounds that is generally present in coppered peas is equal to about 2 to 3 grains of crystallized sulphate of copper per pound ; but a case was heard at Dover where an equivalent to 7·2 grains of sulphate of copper per pound was found,[1] and evidence was given before the Committee on Food Preservatives that as much as 26·5 grains per pound had been detected.

Though the copper compounds present in greened peas are more or less insoluble in water, it does not follow that they are insoluble in the animal fluids, and there is one recorded case where death resulted from the use of coppered peas.[2]

[1] *British Food Journal*, 1901, p. 276.

[2] At the Hartford Colliery, February 4, 1903, an inquest was held on a four-year-old child, whose death was due to acute metallic poisoning, consequent on eating preserved peas greened with copper (*British Food Journal*, 1903, p. 36).

The natural green colouring matter of vegetables is not indefinitely permanent, and if the public had been content to have their preserved peas with a more or less faded appearance, such as is found in dried peas, the objectionable practice of adding compounds of a poisonous metal would probably never have arisen.

CHAPTER XIII

TESTING FOR SALICYLIC ACID

EXPERIMENT XLI. (Time, one and a half hours.)

Salicylic acid is often added as a preservative to jams, wines, etc.

Properties.—1. Place as much as will cover a three-penny-piece in a test-tube.

2. Add about 5 c.c. of cold water, shake, and note whether it dissolves.

3. Gently warm the contents over a Bunsen burner, and note the result.[1]

4. Cool the contents under the water-tap. Note what occurs.

5. Add 5 c.c. of methylated ether to the contents of the tube, place the thumb over the mouth of the tube, and shake. Considerable pressure will be evolved in the tube during the shaking, and the thumb must be kept firmly pressed down. Remove it very gradually when the tube is in an upright position.

NOTE.—As ether is extremely inflammable, it must never be brought within 6 feet of a lighted gas, spirit-

[1] While the solution is still warm, place 1 drop on a white porcelain tile, add 1 drop of ferric chloride solution (5 per cent.), and note the change in colour.

lamp, etc. One part of salicylic acid is soluble in 500 parts of cold water and in 2 parts of ether.

From the above we find that—

Salicylic acid is a light white powder,

Does not readily dissolve in cold water,

Is more readily dissolved in hot water, and crystallizes from its solution as the water cools,

Is very readily soluble in ether, and this liquid can therefore withdraw it from its aqueous solution,

Gives an intense violet colour with a solution of ferric chloride (5 per cent.).

Detection of Salicylic Acid in Jam.

1. Salicylic acid occurs naturally in certain fruits, such as the black currant, but the quantity is so small that its presence would not be detected in the usual quantities taken for analysis.

2. Take about 2 tablespoonfuls of jam (which contains salicylic acid), and mix with about 70 c.c. of water to which 5 drops of dilute sulphuric acid have been added (1 : 4).

3. Filter through coarse muslin, using a funnel $3\frac{3}{4}$ inches in diameter.

4. Transfer the filtrate to the separating funnel.

5. See the tap of the funnel is closed, add carefully 20 c.c. of ether, insert stopper in the funnel, keep it pressed firmly down, and shake gently for half a minute.

6. Bring the funnel to the upright position, and very gradually remove the stopper.

7. The contents of the separating funnel will separate into two layers : the bottom is the aqueous

solution of jam, the top the ethereal solution of salicylic acid.

8. Open the tap, and carefully run off the bottom layer of liquid, which may be thrown away.

9. Collect the top or ethereal solution in a porcelain basin, and allow it to evaporate spontaneously in the air, finishing off over a beaker of hot water.

10. Notice that there is a small quantity of white feathery matter in the basin.

11. Dip a glass rod into the ferric chloride solution, and allow 1 or 2 drops to fall into the basin.

12. An intense violet coloration is produced, which previous experience has shown to be a delicate test for salicylic acid.

In like manner test some home-made jam which does not contain salicylic acid.

CHAPTER XIV

ESTIMATION OF WATER IN BUTTER, MARGARINE, LARD, OR LARD SUBSTITUTE

EXPERIMENT XLII. (Time, two hours.)

For butter and margarine the maximum quantity of water allowed by the Acts is 16 per cent.

There is no legal limit for the quantity of water in lard or lard substitute, but the quantity certainly should not exceed a trace.

Apparatus Required.—Balance and weights, four porcelain basins, four beakers (4 ounces) or four water-tight tins (those in which certain brands of cigarettes are sold are suitable, diameter 2½ inches), four tripod stands, four Bunsen burners, graduated 100 c.c. measure.

Weigh one of the basins, add 1 gramme to the weight, then weigh this quantity of butter; note the weight.

Pour 150 c.c. of tap-water into the beaker or the tin, place it on the tripod stand, and bring to the boil by means of the Bunsen burner. When ebullition commences, lower the gas so that the water just gently boils; place the basin containing the weighed

quantity of butter on the beaker or tin, and let it remain exposed to the steam from the boiling water for one hour. Turn out the gas, remove the basin, carefully wipe the under surface dry, allow it to cool, and weigh. The loss in weight is the water which was present in the butter.

Examine samples of margarine, lard, and lard substitute in the same manner for the quantity of contained water, setting them on as soon as the butter is drying.

A useful confirmatory test for the presence of water in lard or lard substitute is to melt about 1 ounce in a beaker. If the melted fat is clear and free from turbidity, little or no water can be present; but if the melted fat is turbid, it is due either to the presence of water or non-fatty matter, which must be regarded as an impurity.

EXPERIMENT XLIII. (Time about twenty minutes.)

About an ounce of the fat is placed in a beaker (narrow form), and the beaker put in a warm place, such as the top of the hot-water oven. As the fat melts, the water will gradually form a layer in the bottom of the beaker.

EXAMPLE OF THE ESTIMATION OF WATER IN BUTTER.

	Grammes.
Weight of basin and 1 gramme of butter	28·040
Weight of basin	27·040
Weight of butter	1·000

	Grammes.
Weight of basin and 1 gramme of butter before drying	28·040
Weight of basin and butter after drying	27·927
Loss of weight (water)	0·113

One gramme of butter was taken; therefore $0{\cdot}113 \times 100 = 11{\cdot}30$ per cent., the quantity of water contained in the butter.

The water in butter or margarine may be estimated by an alternative method, as described in Experiment XLIV. As the same sample was used for both experiments, it proves that both methods give results which closely agree.

EXPERIMENT XLIV. (Time, one and a half hours.)

Apparatus Required.—Balance and weights, spatula, porcelain basin (diameter $3\frac{1}{4}$ inches), Bunsen burner with rose-top, tripod stand, thermometer (either Centigrade or Fahrenheit; if the former, the scale should extend to 130° C., or the latter to 250° F.).

1. Wash and dry the porcelain basin.

2. Place it on the left-hand pan of the balance and find its weight; note.

3. Place another 25 grammes on the right-hand pan of the balance, and weigh this quantity of butter into the dish.

4. Place the basin containing the 25 grammes of butter on the tripod stand; light the burner fitted with the rose-top, keeping the gas as low as possible.

5. Stir the butter whilst it is melting with the thermometer; do not rub the thermometer-bulb on

the bottom of the dish, but keep it in the middle of the melted butter.

6. When the butter has melted, bubbles will begin to form and will rise to the surface, where they are dissipated into steam.

7. This is the water which the butter contained.

8. Whilst the water is being freely evolved the thermometer will not rise above 100° C. or 212° F.

9. As the water is driven off, the thermometer rises, and care must be taken not to let it rise above 110° C. or 230° F.

10. When the bubbling has practically ceased, turn out the gas, allow the basin and its contents to cool; this may be hastened by placing it on a cool surface, such as an iron slab.

11. When cold, weigh. The loss of weight is water.

12. Example:

	Grammes.
Weight of basin	34·007
Weight of butter	25·000
Total weight of basin and butter before heating	59·007
Total weight of basin and butter after heating	56·220
Loss (water)	2·787

2·787 × 4 = 11·14 per cent. water.

CHAPTER XV

THE MICROSCOPE

The unassisted eye is not able to distinguish very minute objects. For instance, it is quite impossible to tell whether there is any difference in shape or size between the grains of potato starch and rice starch.

The chemical test (Experiment I.) also fails to denote any difference, as both give the same blue colour with iodine solution, which disappears on warming and returns on cooling. (Verify this statement.)

If magnified sufficiently, great differences will be observable both in shape and size. The instrument that is used for this purpose is called a 'microscope.'

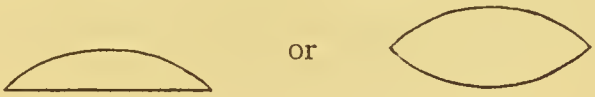
The simplest form of microscope, consisting of only one lens, was known to the Greeks and Romans, for Aristophanes refers to globules of glass which were sold by the grocers of Athens as 'burning spheres.'

No doubt these were derived from a still simpler form of microscope—viz., a drop of water, the magnifying power of which must have been noticed by primitive man.

EXPERIMENT XLV.

Place a drop of water on some small printed matter, say the smaller type of a newspaper, and compare the size of the type under the drop with the original.

The examination of a magnifying-glass shows it to be shaped



1. 2.

1 is known as a plano-convex, 2 as a double convex.

The more convex, the greater will be the magnifying power, and the closer the glass will have to be placed to the object viewed. The compound microscope is based upon this property.

In a compound microscope there are several parts :

The tube to hold the lenses through which the object is viewed.
The focussing arrangement.
The mirror to illuminate the object.
The stage on which the object is placed.
The stand to which the different parts are fastened.

The lenses at the top of the tube constitute what is known as the eye-piece, or ocular. In the lower part is the objective, the magnifying power of which varies.

CHAPTER XVI

MICROSCOPICAL EXAMINATION OF STARCHES

Carefully wash the glass slide, dry, and polish with a chamois leather, the glass being rubbed till free from any trace of grease. This can be ascertained by noting the behaviour of a drop of water placed on its surface ; the drop should spread out, and not remain in the spherical form.

Place a drop of water ◯ on the middle of the surface of the clean dry glass.

Moisten the point end (extending about one-sixteenth of an inch) of an ordinary pin with water, and dip the moistened end into the starch to be examined (a little being removed from the bottle for this purpose). The small quantity of starch that adheres to the pin is mixed with the drop of water on the slide, and then covered with a circular cover-glass (previously cleaned), taking care to let one edge of the cover-glass down first, the other following slowly, in order to prevent the enclosure of air-bubbles in the water.

The slide is now placed on the microscope stage, and examined with a $\frac{1}{4}$-inch objective.

The preparation is brightly illuminated by reflecting the light from the movable mirror underneath the stage.

Now rack the tube down till the front of the objective *almost* but *not quite touches* the cover-glass.

Looking down through the microscope, very slowly and carefully turn the screw handle, so as to raise the objective away from the cover-glass and slide.

At a certain point the grains of starch will appear quite sharp and clear, and are then said to be in focus, the least movement of the tube either up or down from this position putting them out of focus and obliterating the detail.

The beginner generally errs in using too large a drop, with the result that the cover-glass, instead of being fixed to the slide, floats on the surface of the water, some of which usually gets on to the upper surface, wets the front of the objective, and spoils the definition. If too much water has been used, it is best to prepare a fresh slide.

When examining the starches, additional information as to their shape may often be obtained by making them roll. This is effected by gently tapping the top of the cover-glass with the fine point of a pencil or needle whilst the slide is being examined.

It will be found that, not only do the starches differ in shape, but there are great variations in size.

By suitable means the starches may be measured ; the most convenient unit for this purpose is the micron, or $\frac{1}{1000}$ of a millimetre.

Leaving their accurate measurement to a later

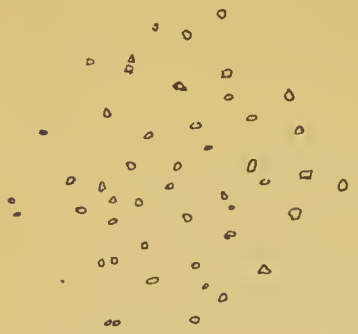


FIG. 1.—RICE.

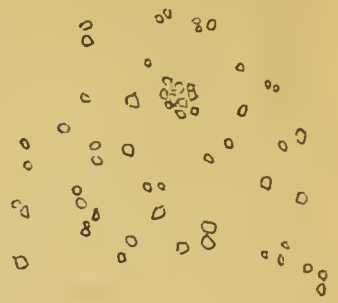


FIG. 2.—OATMEAL.

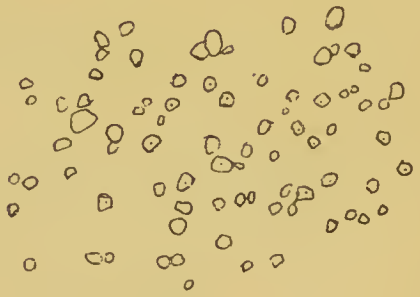


FIG. 3.—MAIZE.

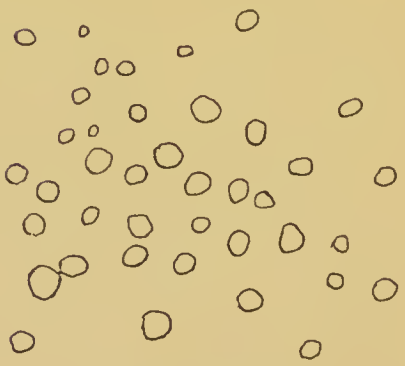


FIG. 4.—BARLEY.

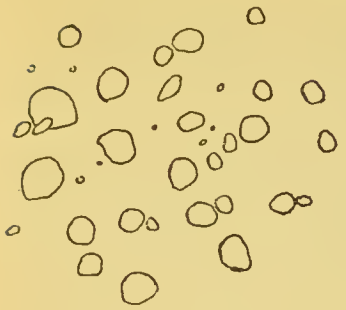


FIG. 5.—WHEAT.

FIG. 6.—PEA.

FIG. 7.—ARROWROOT.

FIG. 8.—POTATO.

stage, it may be useful to give a rough approximation of their respective sizes.

For this purpose we shall take the average size of rice starch as the unit, rice being the smallest of the starches mentioned in this work.

Taking rice as 1,

Oatmeal = 1·7.
Maize = 2·5.
Barley = 3·4.
Wheat = 4·6.
Pea = 5·0.
Arrowroot, or Maranta starch = 6·0.
Potato starch = 12·0.

These numbers must only be taken as approximate, as different grains of the same starch show great variations both in size and shape.

The starches are sometimes classified according to their general shape :

Resembling an oyster-shell or an egg	Potato, arrowroot, pea.
Round	Wheat, barley.
Polygonal (many angles) ...	Maize, oats.
Pentagonal (five angles) ...	Rice.

The outline of the grains being quite sharp, the student should endeavour to sketch them. Place a piece of white paper on the table at the right-hand side of the microscope ; look down the microscope with the left eye, and at the same time look at the paper with the right eye, and with a hard pencil (H) copy the shape and size as far as possible.

The first two or three attempts will probably be failures, but with a little perseverance it will be found quite easy to use the two eyes independently, and with practice very accurate sketches may be thus effected.

Microscopic preparations should be sketched whenever possible, as it is an invaluable means of helping the memory. When examining an unknown starch, always compare it with an authentic specimen of what you suppose it to be.

EXPERIMENT XLVI.

Apply the iodine test described in Experiment I. to potato starch, arrowroot starch, maize starch, rice starch, wheat flour, barley-meal, oatmeal, and peameal. It will be found that all give the same result, and the iodine test is therefore not capable of distinguishing one variety of starch from another.

Make a slide of each, carefully examine under the microscope, and sketch what you see. Very great differences will be observable. Compare your sketches with the drawings on pp. 64 and 65.

CHAPTER XVII

POTATO STARCH, ARROWROOT, MAIZE —RICE, WHEAT FLOUR, BARLEY, OATMEAL, PEAS

Potato Starch, or, as it is sometimes called, British arrowroot, is derived from the well-known vegetable imported into Ireland from America about 1565, and into England twenty years later.

In its natural state the potato contains about 18 per cent. of starch, the greater part of the remainder being water.

The separated starch is largely used in the manufacture of British gum, and also for the production of potato spirit.

Accum states that potatoes are largely used to adulterate bread. Under the name of 'fruit' they still form a component part of baker's bread, the usual quantity being about 3 per cent.[1]

Such small addition can hardly be regarded as an adulteration, especially as it has a specific useful action.

Various authorities mention that potato starch has

[1] 'Chemistry of Cookery,' W. M. Williams, 1885.

been used to adulterate wheat flour,[1] but Hassall did not find it in those he examined, and there are no recorded cases either in the *Analyst* or *British Food Journal.*

Potato starch is the largest of the commonly occurring starches, and its microscopic appearance, together with its size, render it easy to recognize.

With careful focussing the student will notice, especially in the larger grains, a number of concentric rings ; but these are not so well defined as many of the published diagrams would lead one to suppose.

ARROWROOT, or Maranta starch, is obtained from the underground stems (rhizomes) of plants belonging to the Maranta family. They are natives of the West Indies, but are now extensively cultivated in South Africa, Ceylon, etc.

The name 'arrowroot' is of Indian origin, the South American Indians believing that the roots of the plant were an antidote to wounds caused by poisoned arrows. It was not till 1696 that it became known to Europeans, and another sixty years elapsed before the starch was used as a food.

In their natural condition the rhizomes contain about 25 per cent. of starch, which has to be separated from the other parts of the plant and purified before it is in a marketable condition.

Bermuda arrowroot is the highest price, and considered to be the best ; but though there are certain minor differences in the starches derived from the arrowroots of different localities, there is

[1] Normandy's 'Handbook of Chemical Analysis,' 1850, and 'Foods,' by A. Wynter Blyth.

a well-marked family likeness, as is shown by preparing slides of the following varieties of arrowroot: Bermuda, St. Vincent, and Natal. Make careful sketches.

Owing to its comparatively high price, it has been much subjected to adulteration. Accum mentions potato starch as being nearly always present, and Hassall found, in addition, sago and tapioca. Recently maize has been used.

Potato starch, which is the most likely adulterant, may be detected by its size.

The purest arrowroot always contains about 16 per cent. of water, the remainder being starch.

MAIZE, or Indian corn, is of American origin, where it is largely cultivated. Extensive crops are now also grown in South Africa (where it is known as mealies), Southern Europe, and parts of Asia. It belongs to the grass family, and contains about 60 per cent. of starch, which is very different in shape and size to potato or arrowroot.

It is not likely to be adulterated, but is used as an adulterant. In the United States it is known as 'corn,' and the American millers have at variou times exported to this country different consignments of wheat flour containing from 10 to as much as 30 per cent. of maize.

When the student has become acquainted with the microscopic appearance of wheat flour, he should examine wheat flour containing maize to the extent of, say, 20 per cent. Several slides should be made and sketched.

The name of cornflour is purely empirical, as the

substance sold under this name is not the flour of corn, but is the purified starch of maize. The name, however, has the sanction of nearly fifty years' usage, and is recognized as implying a definite substance. Attempts to supply rice starch or potato starch when cornflour has been asked for have resulted in the conviction of the vendors.[1]

Maize is very often present in the so-called 'self-raising flours, and cornflour forms the basis of a number of prepared foods for infants, etc.

Rice.

'Rice—what will this sister of mine do with rice?'
The Winter's Tale.

'This is a Seed of so great Use and Profit that it may be called the Manna of the Poor, and throughout several entire Countries they have scarce anything else to subsist on.'—POMET'S *History of Drugs*, 1748.

Rice is a native of India, where it is grown on an enormous scale. China, Japan, and Central America also produce much rice. It is more largely grown than any of the other cereals, and forms the main food of at least one-third of the human race.

It contains about 75 per cent. of starch, which somewhat resembles maize in shape, but is much smaller, rice being the smallest of the cereal starches.

When submitted to microscopic examination, it will be found that rice starch has a tendency to form 'compound' grains—*i.e.*, a number of the small grains adhere together, and form what at first appears to be one large grain. Careful focussing will, however, dispel any uncertainty, and in order to prevent mis-

[1] *British Food Journal*, 1902, pp. 257, 269; and 1907, p. 29.

takes the cover-glass should be gently pressed, applying at the same time a slight circular movement, observations being made before and after this treatment.

Owing to its cheapness, rice is not liable to be adulterated, but is used as an adulterant of other substances, such as pepper and wheat flour.

The *British Food Journal*, 1903, p. 93, gives a case where ground rice was found to be adulterated with 15 per cent. of maize.

In 1906 Cribb and Richards drew attention to the 'facing' or polishing of rice grains with a mineral substance of the nature of talc. This practice appears to have been prevalent for many years, and had not been suspected, except vaguely, till the publication of this paper in the *Analyst* for 1906, p. 40.

The detection of such adulteration is beyond the scope of the present work, but Messrs. Cribb and Richards' concluding paragraph is worth quoting: 'It is somewhat startling to reflect that an article of diet of such common and widespread use, hitherto accepted as one of the purest forms of vegetable food, should so frequently contain a substance of a foreign nature.'

Wheat Flour.

'. . . Two grains of wheat hid in two bushels of chaff: you shall seek all day ere you find them; and when you have found them, they are not worth the search.'—*Merchant of Venice.*

Wheat was known to the Egyptians 2,000 years ago, but its original habitat is quite uncertain.

Like maize and rice, it belongs to the grass family,

and contains a large quantity of starch of a distinctive shape and size.

When subjected to an elaborate process of milling and sifting it yields, amongst other products, wheat flour, or, as it is commonly called, 'flour,' which contains about 70 per cent. of starch.

Hassall did not find wheat flour to be adulterated with other starches, and, with the exception of the addition of maize and rice, there are but few recorded cases.

The *Analyst*, 1880, vol. v., p. 174, mentions a conviction in Ireland for selling flour adulterated with oat flour and also containing fungi.

Reference to the *British Food Journal* for 1902 shows a number of convictions for supplying wheatmeal or 'wholemeal flour' containing 12 to 20 per cent. of bran in place of wheat flour.

Amongst the mineral adulterants, alum has had an extensive application, the addition of talc has been suspected, and during the present year (1910) it has been stated that calcium phosphate is being used.

Another modern form of adulteration, which had its origin in America, is the bleaching of inferior flours in order to make them resemble those of superior quality.

Microscopic examination will show wheat starch to consist of large rounded grains mixed with a number of very small grains. When made to roll, the large grains have a distinct bun-like shape.

Barley.

There is an Eastern tradition that barley was the first of the grass family, or cereals, to be used for human consumption.

It was the staple cereal of the ancient Britons, and down to as late as 1626 (Charles I.) 'barley bread was the usual food of the ordinary sort of people' (Hassall). Now its principal use is for the preparation of malt.

Barley is rarely adulterated, but has been used as an adulterant for oatmeal.

Microscopic examination shows that barley starch closely resembles that of wheat both in size and shape, but the *large* barley grains are a little *smaller* than the *large* wheat grains, and have not quite such a regular shape.

Oatmeal.

'I had as lief you would tell me of a mess of porridge.'
Merry Wives of Windsor.

The oat is another member of the cereals—a family which has been of incalculable service to the human race. Like wheat, its native country is unknown.

Though not used by mankind to anything like the extent of rice or wheat, it is largely consumed in the form of porridge, oatcake, and Yorkshire parkin.

Oatmeal is prepared by first kiln-drying the grain, which renders the husk easy of removal; it then goes through a milling process, and finally the purified grain is crushed, in which form it is sold for food purposes.

The main adulterant of oatmeal is barley, the presence of which may be detected by the microscope.

Oat starch is one of the smaller starches, not much larger than rice, which it closely resembles in shape and also in its tendency to form 'compound' grains. In examining oatmeal the same precautions must therefore be adopted as when examining rice; otherwise the compound grains may easily be taken for those of barley.

Peas.

'I had rather have a handful or two of dried peas.'
Midsummer Night's Dream.

Peas are the seeds of a leguminous plant which, though resembling the cereals in containing much starch, differs in containing far more albuminoids, or flesh-formers. The albuminoid substances which are present are known as legumin or vegetable casein.

In the *Analyst*, 1905, vol. xxx., p. 206, it is stated that dried peas have been found in some instances to have been coated with talc. Excluding the colouring of peas with copper compounds, there is little or no adulteration.

The student should prepare slides and sketch the appearance of pea starch prepared from pea-meal or from a dried pea.

CHAPTER XVIII

MUSTARD

GRU. What say you to a piece of beef and mustard ?
KATH. A dish that I do love to feed upon.
GRU. Ay, but the mustard is too hot a little.
KATH. Why, then, the beef, and let the mustard rest.
GRU. Nay, then, I will not : you shall have the mustard,
Or else you get no beef of Grumio.
KATH. Then both, or one, or anything thou wilt.
GRU. Why, then, the mustard without the beef.

Taming of the Shrew.

THIS well-known condiment is the fine yellow flour obtained from the black and white mustard seeds, generally mixed. The seeds are crushed, ground, and passed through a series of sieves, the finest portion constituting the superfine mustard for table use.

Mustard has been known in its present form since 1720, when Mrs. Clements, who lived in Durham, prepared it as above described. Prior to that year the seeds had been simply pounded in a mortar, and the coarser portions rejected.

Mrs. Clements' preparation received the approval of George I., and 'Durham mustard,' as it was then called, soon superseded the older product.

Accum, in 1820, found that 'genuine mustard,

either in powder or in the state of a paste ready for use, is perhaps rarely to be met in the shops. The article sold under the name of "Genuine Durham Mustard" is usually a mixture of mustard and common wheaten flour, with a portion of cayenne pepper and a large quantity of bay salt, made with water into a paste ready for use.'

Hassall, in 1855, wrote : '1. That genuine mustard, whatever be the price paid for it, is scarcely ever to be obtained. 2. That the whole of the forty-two samples submitted to examination were adulterated. 3. That the adulteration practised in every case was the same in kind, varying only in degree, and consisted in the admixture of genuine mustard with immense quantities of wheaten flour highly coloured with turmeric.'

Mustard cannot be said to be extensively adulterated at the present time, but the pages of the *Analyst* and *British Food Journal* record a number of convictions for the sale of mustard containing, in some instances, as much as 60 per cent. or even 70 per cent. of starchy matter, generally wheat flour.[1]

Many of these cases appear to have arisen from the custom of supplying *mustard condiment* when *mustard* (which implies pure mustard) had been asked for.

Mustard condiment is admittedly a mixture of mustard and wheat flour, with very often a little turmeric. It should never be supplied without a label clearly stating that it is an admixture, and the

[1] *Analyst*, vol. vii., p. 90; Allen's 'Commercial Organic Analysis,' 1896, vol. iii., part 3, p. 118.

purchaser should have his attention drawn to the fact before the purchase.

Ripe mustard seed contains no starch. Any starchy addition, such as wheat flour, is therefore readily detected by the iodine test, and also by a microscopic examination.

EXPERIMENT XLVII. (Time, fifteen minutes.)

Weigh approximately $\frac{1}{2}$ gramme of mustard, place it in a test-tube, half fill the tube with water, mix by shaking, just heat to boiling, then nearly fill the test-tube with cold water, mix, and filter through a 9 centimetre filter-paper into a small flask. Test the filtrate for starch by the addition of 1 or 2 drops of iodine solution, as in Experiment I., remembering the precautions to be observed. As little as 2·5 per cent. of wheat flour may thus be detected.[1]

Prepare a slide of pure mustard, and also one of mustard condiment; but, instead of using water as the mounting medium, use 1 drop of the iodine solution diluted with 1 drop of water.

After carefully putting on the cover-glass, drain off the excess of liquid by touching the rim of the cover-glass with a piece of filter-paper. Then, by means of one of the fingers, apply very gentle pressure to the cover-glass, and at the same time a slight circular motion, in order to break down the small lumps of mustard.

Examine the preparation with, first, a low-power objective ($\frac{2}{3}$-inch), and then with the $\frac{1}{4}$-inch objective.

[1] This quantity is allowed in the United States.

In the mustard condiment the grains of wheat starch will be coloured blue, and will be very noticeable against the yellow background; in the pure mustard no such grains will be found.

Owing to the presence of a large quantity of oil, naturally present in mustard, it is necessary to stain the starch grains as described; otherwise they might be confused with the round oil globules, of which a number will be seen unaffected by the action of the iodine solution.

Make sketches, indicating the stained starch grains by shading.

Microscopic examination will easily detect $2\frac{1}{2}$ per cent. of wheat starch.

CHAPTER XIX

STARCH IN YEAST

In the North of England most of the bread is home-made, and German yeast is used in order to cause the dough to rise. Though freed from extraneous liquid as far as possible, it still contains much water, and samples are occasionally met with which have been incorporated with starch, evidently added as a drier, and also, no doubt, to whiten and improve its appearance.

If the yeast has been properly prepared by filtering and pressing, such addition is unnecessary, and renders the vendor liable to prosecution for selling adulterated yeast, such yeast generally containing from 10 per cent. to 40 per cent. of starch.

Experiment XLVIII. (Time, ten minutes.)

As much yeast as will lie on a threepenny-piece is placed in a test-tube. Fill the tube about one-third full with water, thoroughly mix by shaking, and then heat over a Bunsen burner just to boiling, to 'crack' the starch ; cool under the water-tap, and add 2 or 3 drops of iodine solution. A blue colour will indicate the presence of starch. Destroy the colour by heating and restore by cooling, as in Experiment I.

Prepare a slide of the yeast for microscopic examination, but, before putting on the cover-glass, moisten the preparation with 1 drop of iodine solution. The starch cells will be coloured blue, and thus may be readily distinguished from the yeast cells. The starch that is generally used is potato.

GLOSSARY

Acid, acetic—The active principle in vinegar.
Acid, boracic or **boric.**
Acid, carbolic—Phenol.
Acid, hydrochloric or muriatic—Spirit of salt.
Acid, nitric—Aqua-fortis.
Acid, sulphuric—Oil of vitriol.
Ammonia—Spirit of hartshorn.
Ammonium chloride—Sal ammoniac.
Calcium hypochlorite—'Chloride of lime' or bleaching powder.
Copper sulphate—Blue vitriol or blue stone.
Ferrous sulphate—Green vitriol or copperas.
Lead acetate—Sugar of lead.
Magnesium oxide—Calcined magnesia.
Magnesium sulphate—Epsom salts.
Potassium hydrogen oxalate—Salts of lemon or salts of sorrel.
Potassium nitrate—Saltpetre.
Potassium bitartrate—Cream of tartar.
Potassium sodium tartrate—Rochelle salt.
Sodium hydrogen carbonate—Bicarbonate of soda.
Sodium hydrate—Caustic soda.
Sodium borate—Borax.
Sodium chloride—Common salt.
Sodium sulphate—Glauber's salts.

Chalk—Calcium carbonate.
Gypsum—Calcium sulphate.
Common alum—Aluminium potassium sulphate.
Sand—Silica or siliceous matter.
Washing soda—Crystallized sodium carbonate.
Methylated spirit—Ethyl alcohol containing certain impurities to render it unfit for drinking.
Beet-sugar or **cane-sugar**—Sucrose.
Grape-sugar—Glucose.
Colza oil—Rape oil.
Sweet oil—May be arachis oil, cotton-seed oil, sesame oil, or olive oil, or a mixture of any or all of the above.

COMPARISON BETWEEN ENGLISH AND FRENCH MEASURES AND WEIGHTS, Etc.

(Many of the numbers have been approximated in order to render them easier to commit to memory.)

1 inch	=	2·5 centimetres.
1 foot	=	0·3 metre.
1 cubic inch ...	=	16·4 cubic centimetres.
1 cubic foot ...	=	28·3 litres.
1 pint	=	0·5 litre.
1 gallon	=	4·5 litres.
1 grain	=	0·06 gramme.
1 ounce avoirdupois	=	28·3 grammes.
1 pound avoirdupois	=	453·6 grammes.
1 hundredweight...	=	50·8 kilogrammes.

1 centimetre ...	=	0·4 inch.
1 metre	=	39·4 inches.
1 cubic centimetre	=	0·06 cubic inch.
1 litre	=	61 cubic inches or 1·75 pints.
1 gramme	=	15·4 grains.
1 kilogramme ...	=	2·2 pounds.

Firkin of butter ...	=	56 pounds.
Firkin of soft soap	=	64 pounds.
Bushel of lentils ...	=	63 pounds.
Bushel of ground oats	=	30 pounds.
Bushel of bran ...	=	17 pounds.
Bushel of salt ...	=	65 pounds.
A sieve of currants (Covent Garden)	=	20 quarts.

CONVERSIONS OF MEASURES AND WEIGHTS, Etc.

FACTORS.

Inches	× 2·5	=	Centimetres.
Gallons	× 4·5	=	Litres.
Grains	× 0·065	=	Grammes.
Centimetres	× 0·4	=	Inches.
Litres	× 0·22	=	Gallons.
Grammes	× 15·4	=	Grains.
Kilogrammes	× 2·2	=	Pounds.

THERMOMETER SCALES

Centigrade Scale : Water freezes at 0° and boils at 100° C.
Fahrenheit Scale : Water freezes at 32° and boils at 212° F.

$$C° \times \frac{9}{5} + 32 = F°.$$

$$F° - 32 \times \frac{5}{9} = C°.$$

DIAGRAMS

THE following diagrams show the appearance of the respective starches already described when examined with a comparatively *high* magnifying power. They are taken from 'A Compendium of Food-Microscopy,' by kind permission of the author, Mr. E. G. Clayton, F.I.C., F.C.S. The diagrams on pp. 64 and 65 were drawn, using a *low* magnifying power.

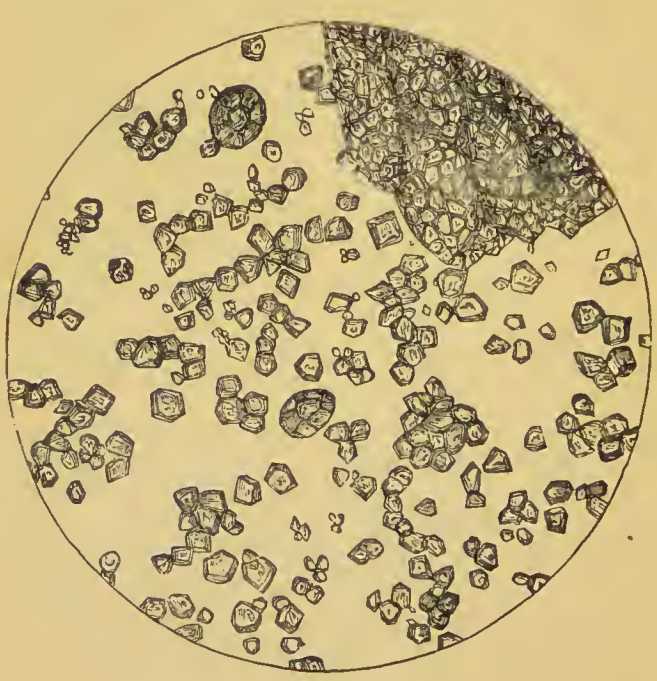


FIG. 9.—RICE.

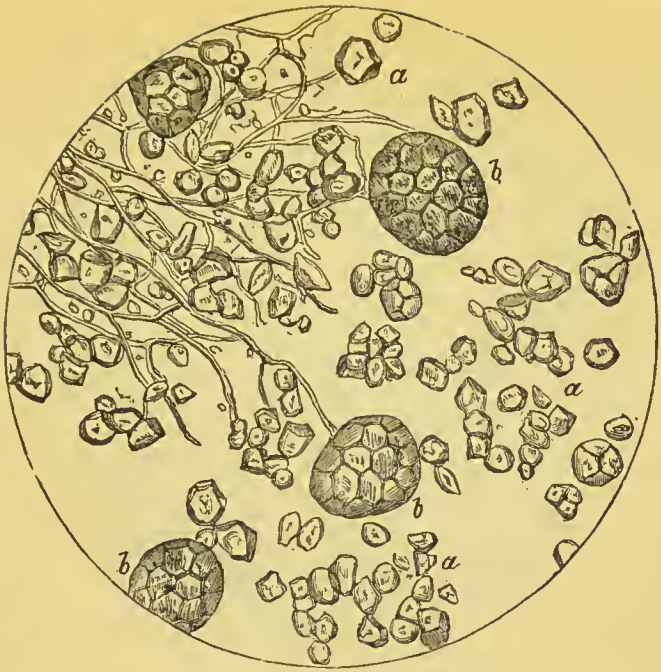


FIG. 10.—OAT FLOUR.

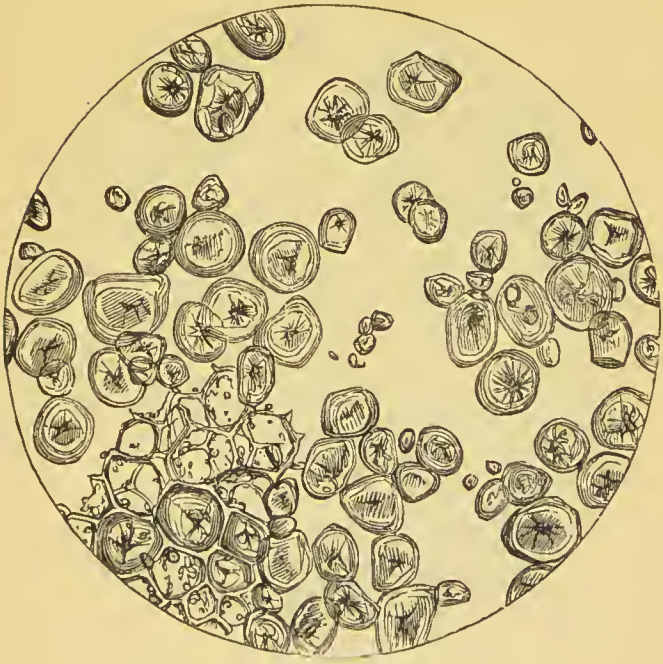


FIG. 11.—MAIZE, OR INDIAN CORN.

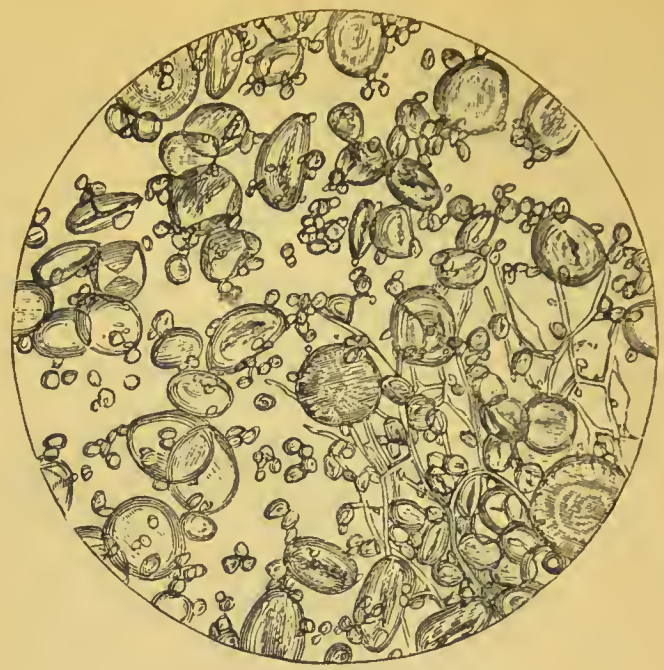


FIG. 12.—BARLEY FLOUR.

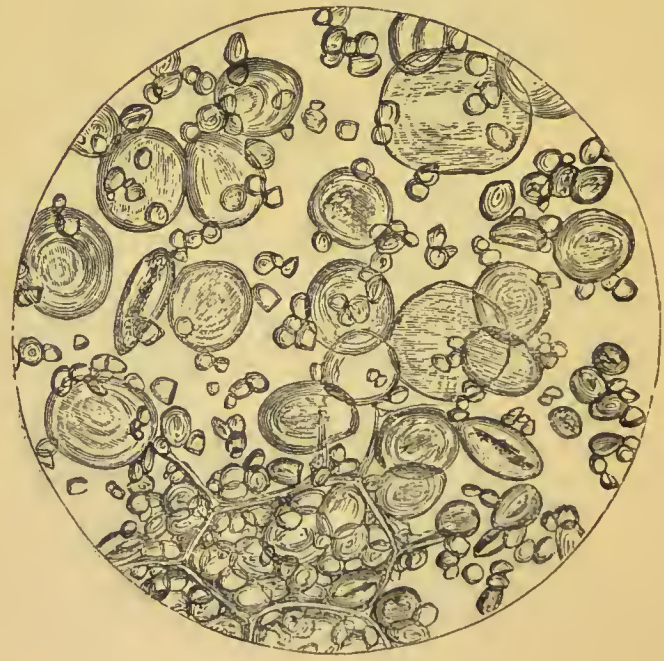


FIG. 13.—WHEAT FLOUR.

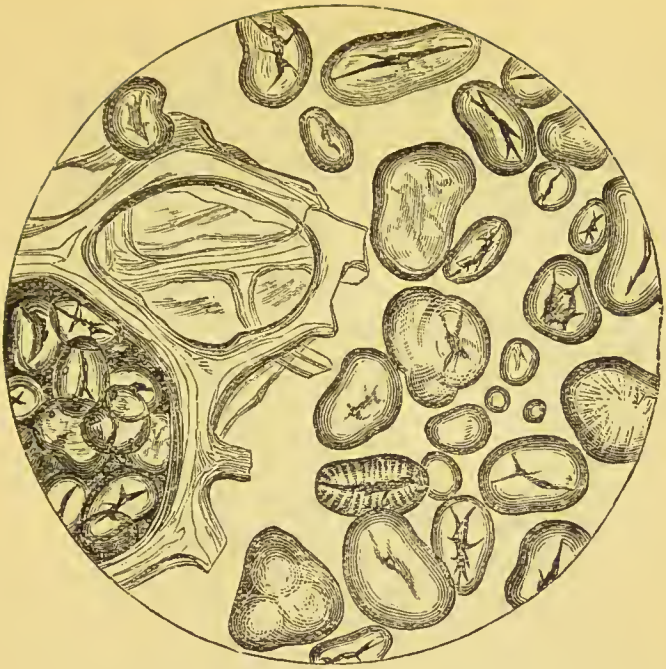


FIG. 14.—BEAN.

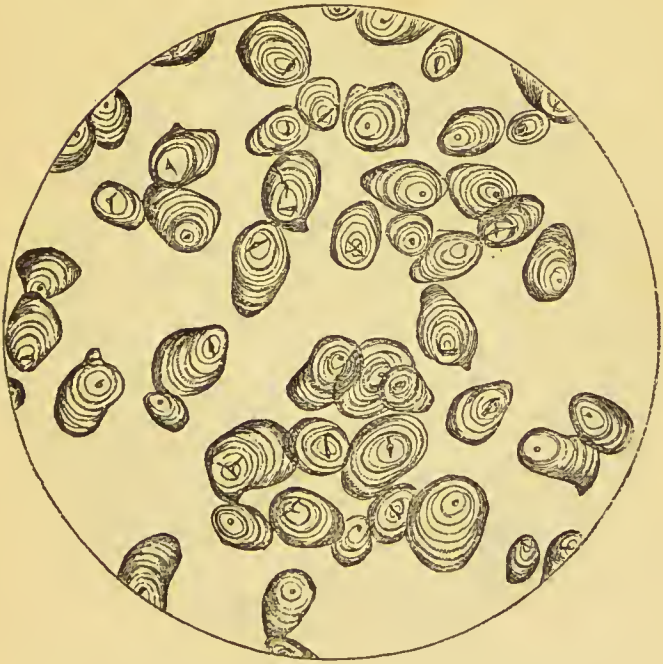


FIG. 15.—MARANTA, OR WEST INDIAN ARROWROOT.

FIG. 16.—POTATO STARCH.

FIG. 17.—OAT FLOUR ADULTERATED WITH BARLEY.

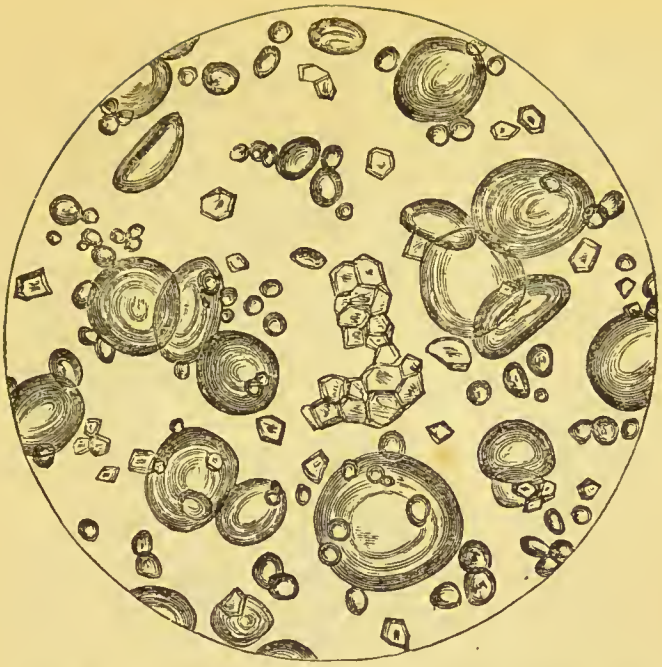


FIG. 18.—WHEAT FLOUR ADULTERATED WITH RICE.

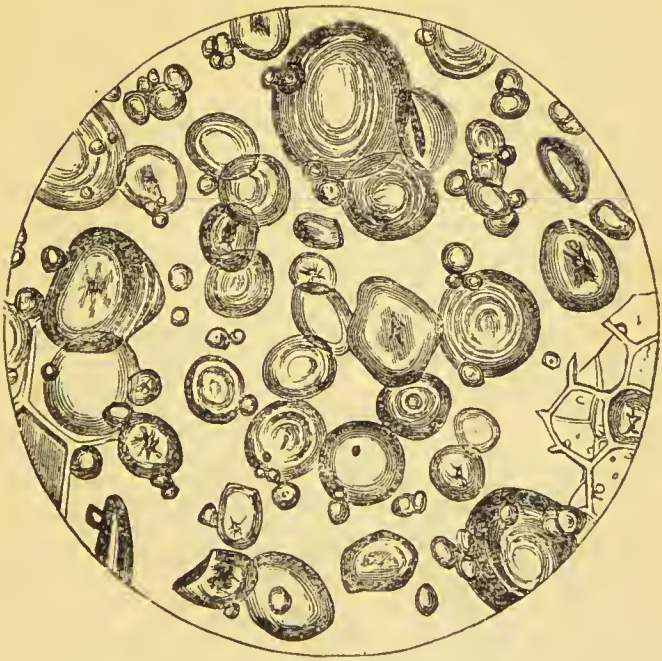


FIG. 19.—WHEAT FLOUR AND MAIZE.

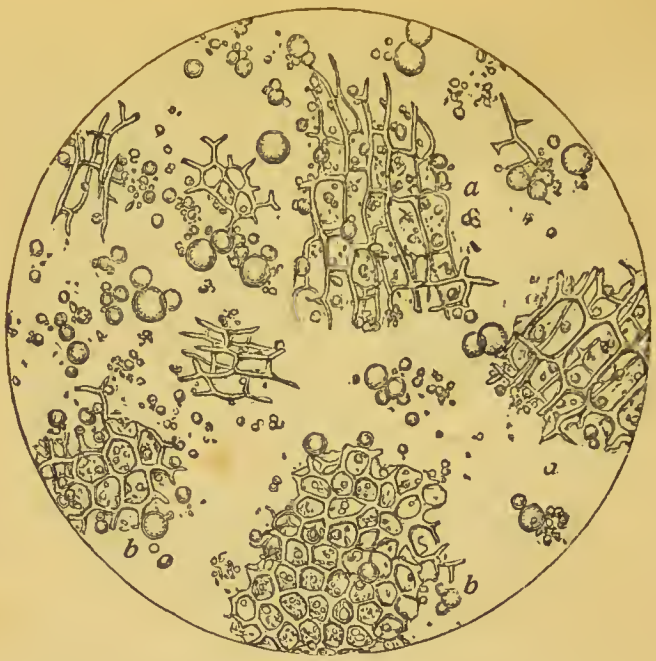


FIG. 20.—MUSTARD.

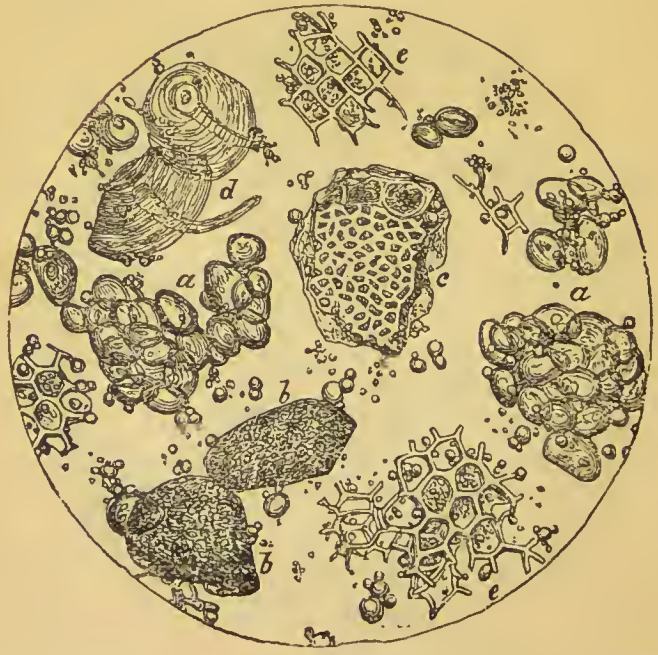


FIG. 21.—MUSTARD, WITH WHEAT FLOUR AND TURMERIC.

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